# The prof who put off a trip to Europe

He had his tickets. He was all set to sail.

Then this professor of engineering at one of America's leading educational institutions received an invitation to General Motors Engineering Educators Conference.

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Q.E.D.—he was delighted. Said he wouldn't have missed it.

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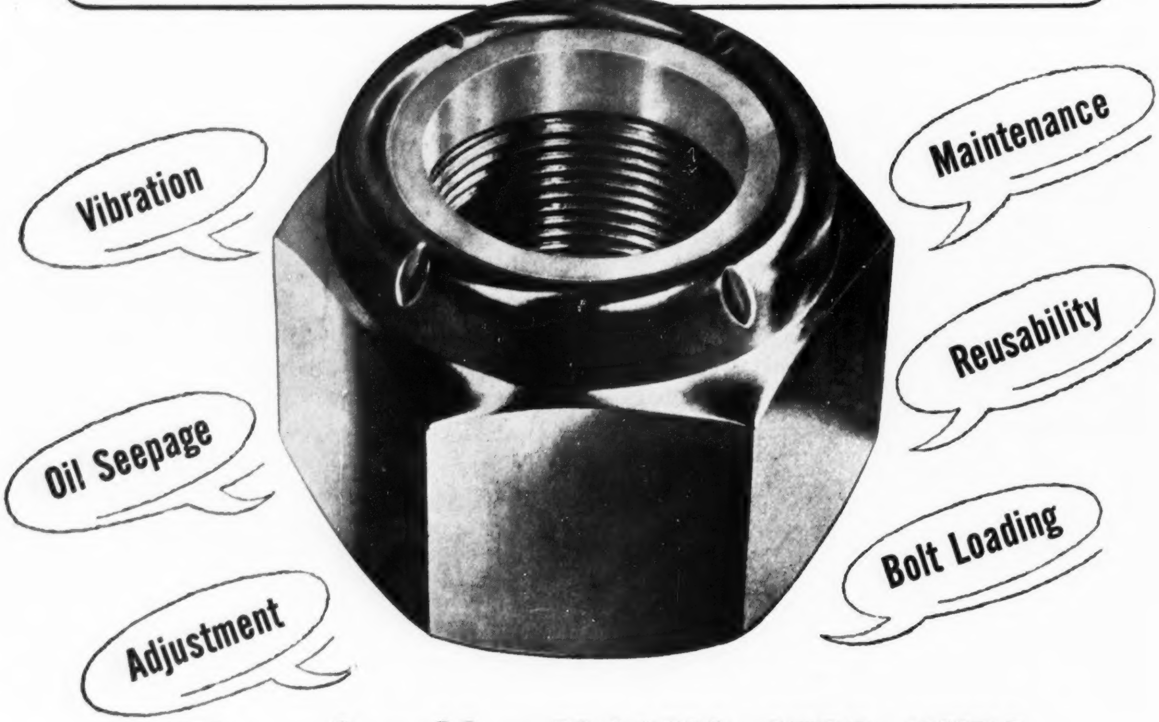


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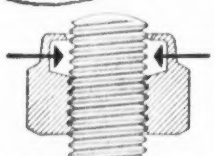

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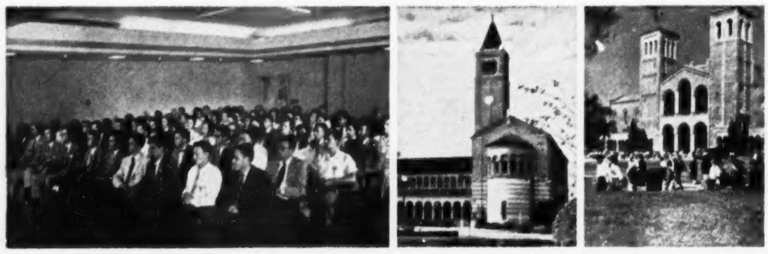
*for Master of Science Degrees*



**A group of participants in the Hughes Cooperative Fellowship Program (above left). Fellows study for Master of Science degrees at either University of Southern California (center) or University of California at Los Angeles (right).**

This program is to assist outstanding individuals in studying for the Master of Science Degree while employed in industry and making contributions to important military work. It is open to students who will receive the B.S. degree in Electrical Engineering, Physics or Mechanical Engineering during the coming year and to members of the Armed Services being honorably separated and holding such B.S. degrees.

Candidates must meet entrance requirements for advanced study at the University of California at Los Angeles or the University of Southern California. Participants will work full time at the Laboratories during the summer, and 25 hours per week while pursuing a half-time schedule of graduate study at the university.

The salary will be commensurate with the individual's ability and experience. Tuition, admission fees and books for university attendance will be provided. Provision is made for an allowance to assist in paying traveling and moving expenses from outside the Southern California area.

## 2 THE HOWARD HUGHES FELLOWSHIPS

*in Science and Engineering*

**(From left to right) Hughes 1952 Fellows Truman O. Woodruff and Allen I. Ormsbee discuss tube processing station in Electron Tube Laboratory with 1953 Fellows Roy Gould and Baxter H. Armstrong. Their advanced study is at California Institute of Technology (above).**

Eligible for these fellowships are those who have completed one year of graduate study in physics or engineering. Successful candidates must qualify for graduate standing at the California Institute of Technology for study toward the degree of Doctor of Philosophy in physics or engineering. In summers they will work full time in the Hughes Laboratories in association with scientists and engineers in their fields.

Fellows may pursue graduate research in the fields of physics, electronics engineering, electronic computing, aerodynamics, propulsion engineering, mechanical engineering, or information theory.

Each appointment is for twelve months and provides a cash award, a salary, and tuition and research expenses. A suitable adjustment is made when financial responsibilities of the Fellow might otherwise preclude participation in the program.

**HOW TO APPLY:** *For complete information concerning either of these Hughes Fellowship programs, consult your Placement Officer or write directly to us. Please indicate the particular program in which you are interested. A detailed explanatory brochure and application forms will be mailed promptly.*

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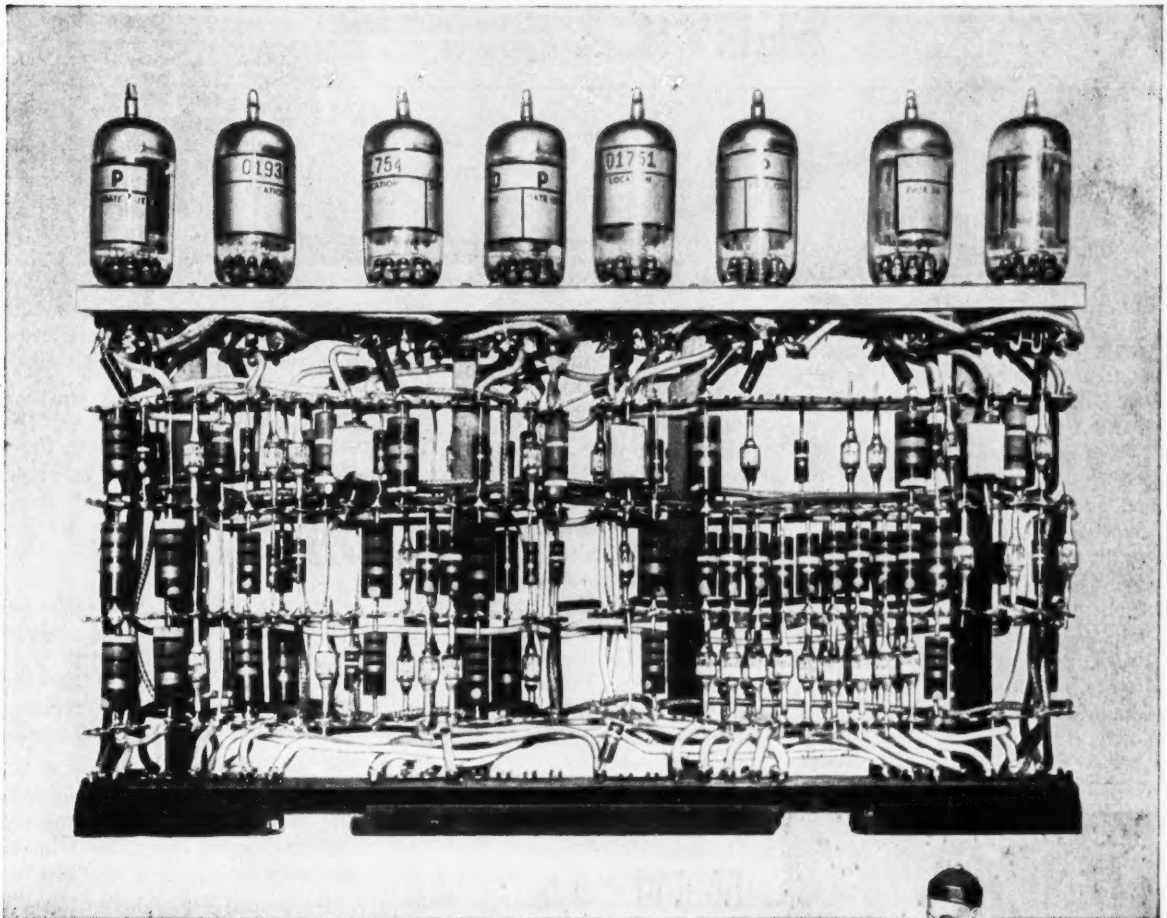

# MODERN ABACUS

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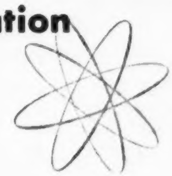

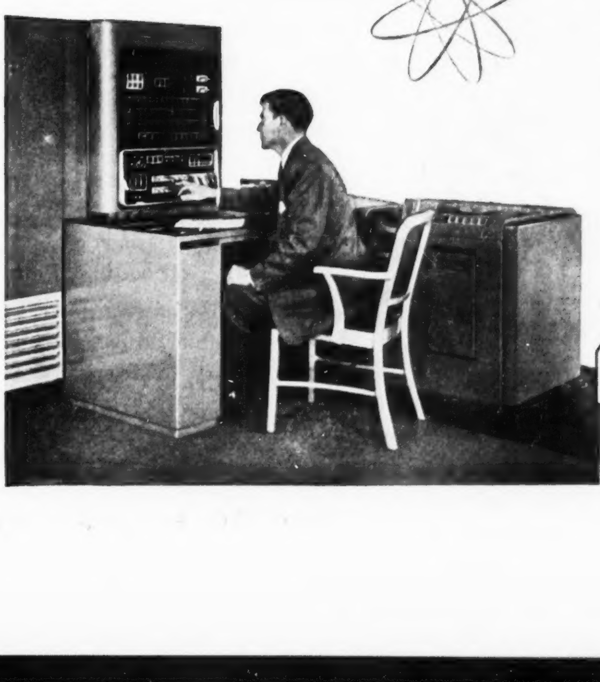

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The United States Civil Service Commission has announced that there is a need for Aeronautical Engineers for research positions with the Air Force Cambridge Research Center and other federal agencies in the New England States. The salaries range from $4,205 to $7,040 a year.

Appropriate education or experience is required. No written test will be given. Further information may be secured at any post office, or from the U. S. Civil Service Commission, Washington 25, D.C. Applications will be accepted by the Board of U. S. Civil Service Examiners, Air Force Cambridge Research Center, 230 Albany St., Cambridge 39, Mass., until further notice.

### Draftsman

The United States Civil Service Commission has also published a new examination for Engineering Draftsman and Statistical Draftsman for filling positions in various Federal agencies in Washington, D.C., and vicinity. The salaries range from $2,750 to $5,940 a year.

### Cartographer

Examinations have also been announced by the U. S. Civil Service Commissions for Cartographer, Cartographic Technician, and Cartographic Draftsman, for filling positions in various Federal agencies in Washington, D. C., and vicinity. Some field-service-at-large positions throughout the United States may also be filled. The salaries of the positions range from $2,750 to 10,800 a year.

The Rome Air Development Center has challenging jobs for Electrical Engineers at salaries from $5040 to $9600 a year in all phases of electronic research and development, and in the installation and maintenance of radio, radar, and wire communications equipment.

Write the Professional and Scientific Recruiter, Rome Air Development Center, Griffiss Air Force Base, Rome, New York, or phone Rome-3200.

## Kodak Fellowships

Eastman Kodak Company has awarded fellowships to 17 educational institutions for the year, 1953-54. This is part of the company's assistance to promising young scientists to encourage training in chemical research.

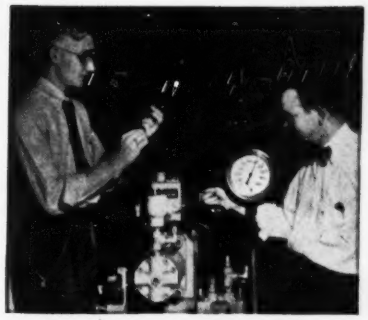
All for advanced study, ten of the fellowships are in chemistry, four in physics, and three in chemical engineering.

Each award provides $1,400 plus an allowance for tuition and fees. The fellowship also provides for a payment of $1,000 to the university to help support the cost of the research undertaken by the student during the period of the fellowship.

The fellowships are awarded to the colleges. They select a research student in the last year of study for his doctorate. The only requirement is that the student be deserving and promising.

Kodak established the fellowships in 1939. For 1953-54, they will be awarded to Brown University, University of Maryland, University of Michigan, University of Minnesota, University of Rochester, University of Texas, University of Washington (Seattle), University of Wisconsin, Yale University, University of Chicago, Cornell University, Harvard University, Massachusetts Institute of Technology, University of Delaware, Iowa State College, and Ohio State University.

# THE DU PONT DIGEST



**The characteristics** *of a super-pressure pump, designed by Du Pont engineers and made in Du Pont shops, are studied by Ralph C. Grubb, B.S.M.E., Tennessee '51, and Paul D. Kohl, B.S.M.E., Purdue '46.*

# Design
## AND DEVELOPMENT

### Call for Knowledge, Ingenuity, Teamwork

Making new products in large amounts, devising new processes, and improving old ones—such problems are the job of Design and Development. An example was the development of a large-scale process for making "Orlon" acrylic fiber starting from small laboratory samples of polyacrylonitrile.

Quantity production of polymer was only a beginning. A whole set of new and unusual problems arose in spinning the fiber, because polyacrylonitrile decomposes before it melts, and it dissolves only in high-boiling solvents.

A team of Du Pont technical men—chemical and mechanical engineers, instrumentation specialists, metallurgists, and materials handling experts undertook to find a solution. Here are a few of the problems they met:

**1.** Solve problems in heat transfer and fluid flow arising from the fact that the spinning solution must be blanketed with inert gas to prevent fire hazards.

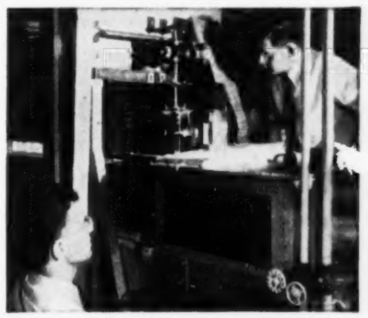
**2.** Design a system for controlling the temperature of the viscous spinning solution within ±0.5°F. at hundreds of points in the plant.

**3.** Design new mechanisms for winding yarn at high speed without any deviation in yarn tension.

**4.** Design air conditioning and ventilating systems to remove fumes from specific spots, but still allow easy access to all areas.

Among Du Pont's many research and engineering activities, Design and Development jobs provide great opportunity for the knowledge, ingenuity, and teamwork capacities of men in a great variety of technical fields.

**Albert Rand,** *B.S.M.E., M.I.T. '50 (right) develops controls for chemical equipment.*



**Carl Hellman,** *B.S.Ch.E., Syracuse '50, and J. M. McKelvey, Ph.D.Ch.E., Washington '50, search for new ways to coat plastic on wire.*

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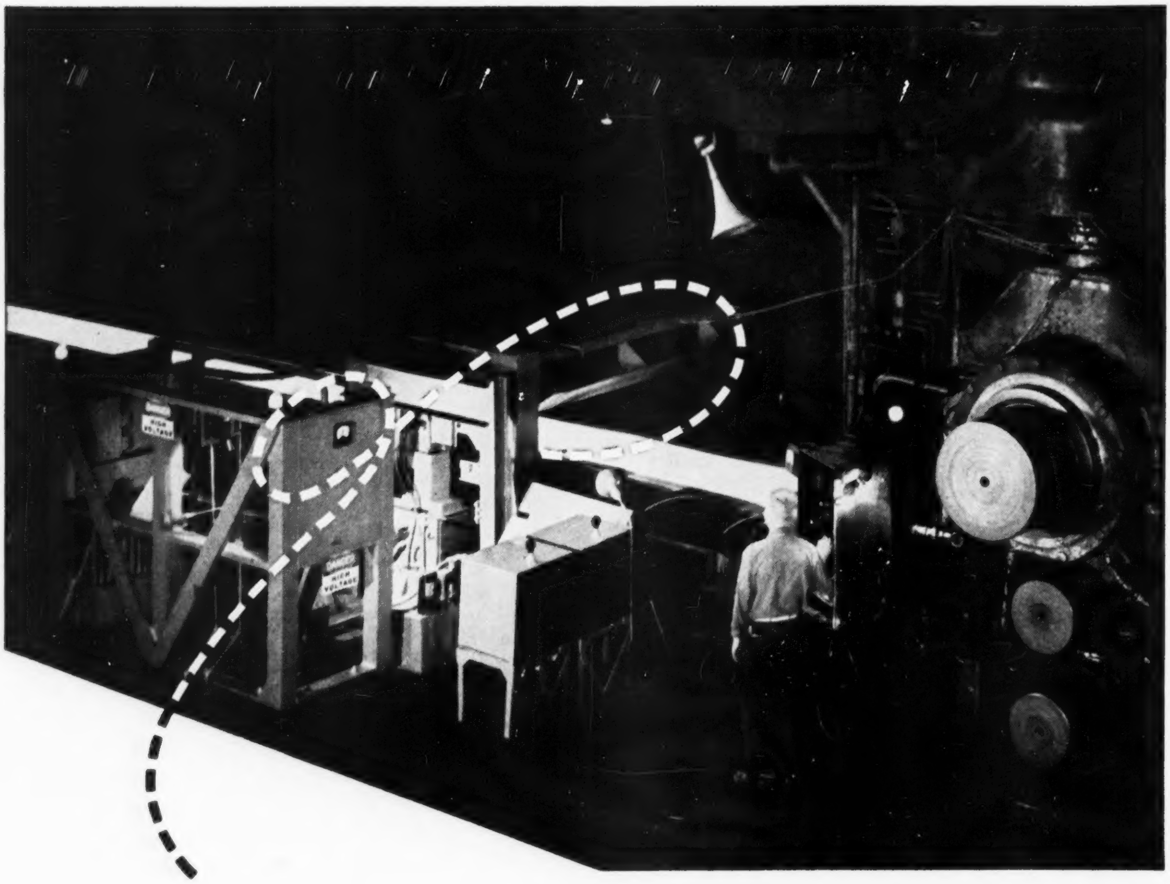

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THE CORNELL
engineer

NOVEMBER, 1953 VOLUME 19 NUMBER 2





COVER—Surveying at Camp Cornell.

—*Alan F. Cohen*

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# Alcohol From Ethylene

By LAVONNE OLSON, Chem E '57

The conversion of ethylene into alcohol is not a new one. It has been known in the laboratory since Faraday and Honnel first reacted ethylene and sulfuric acid to abtain ethyl achohol in 1850. It was not until 1935, however, that the first plant for synthesizing alcohol on a commercial scale was built by Union Carbide and Carbon, although a similar process for making propyl alcohol from propylene had already been in use for several years.

The first oil refinery to use by-product ethylene to manufacture alcohol was the Baton Rouge plant of the Standard Oil Company of Louisiana which opened in 1943. Since then six major refineries have installed this process with several others under construction. This article will deal with the problem of the conversion of this product of the petroleum cracking towers into an industrial chemical.

In the last fifteen years the synthesis of ethyl alcohol from ethylene has become a very important source of industrial alcohol. Fifty-seven per cent of our national production was made in this way in 1952 and future needs indicate an even greater supply of synthetic alcohol, expected this year to climb to sixty-five per cent or more. The details of operating and processing will be given later, but briefly, the process consists of treating ethylene with sulfuric acid to form mono- and diethyl sulfates, and their subsequent hydrolysis to alcohol.

Alcohol plant, Houston, Texas.
—*Shell Chemical*

Next to alcohol, the most important use of ethylene is in making ethylene oxide and its chief derivative, ethylene glycol. The importance of ethylene oxide is due to its usefulness as an intermediate in making many other chemicals, such as ethylene cyanohydrin, acrilonitrite, vinyl chloride, and others.

The most widely used method of making ethylene oxide is to treat ethylene with aqueous hypochlorous acid to form ethylene chlorohydrin. This is then treated with lime at an elevated temperature. The oxide passes off as a gas which is then condensed and purified by distilling. This method, which is schematized in the following equations, results in about eighty per cent yield.

$$CH_2{=}CH_2 + HOCl \rightarrow \underset{OH}{\underset{|}{CH_2}}-\underset{Cl}{\underset{|}{CH_2}}$$

$$2\,\underset{OH}{\underset{|}{CH_2}}-\underset{Cl}{\underset{|}{CH_2}} + Ca(OH)_2 \rightarrow$$

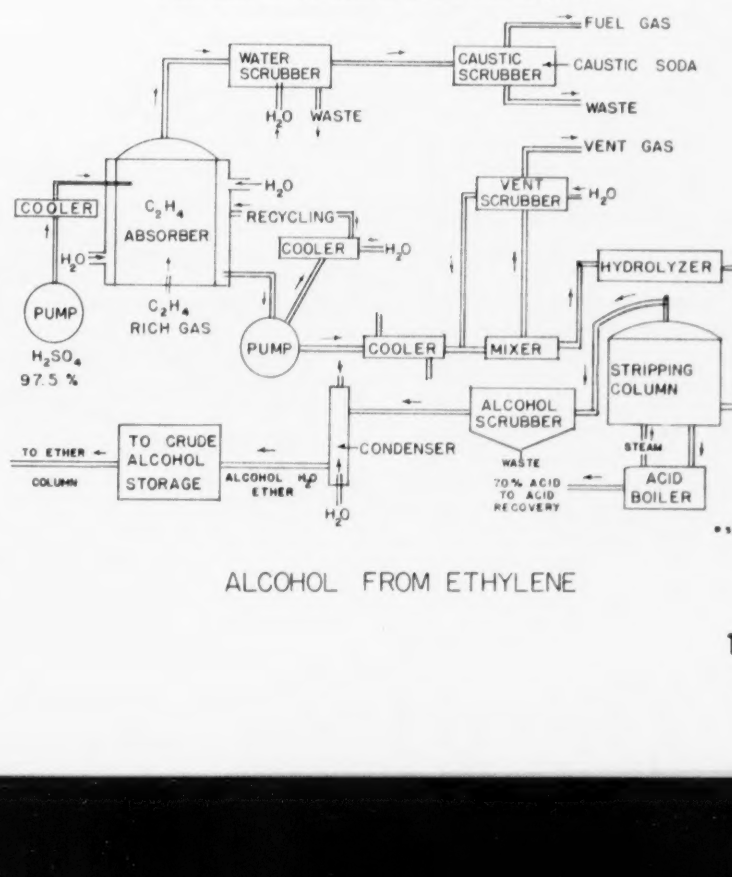
$$2\,\underbrace{CH_2-CH_2}_{O} + CaCl_2 + 2H_2O$$

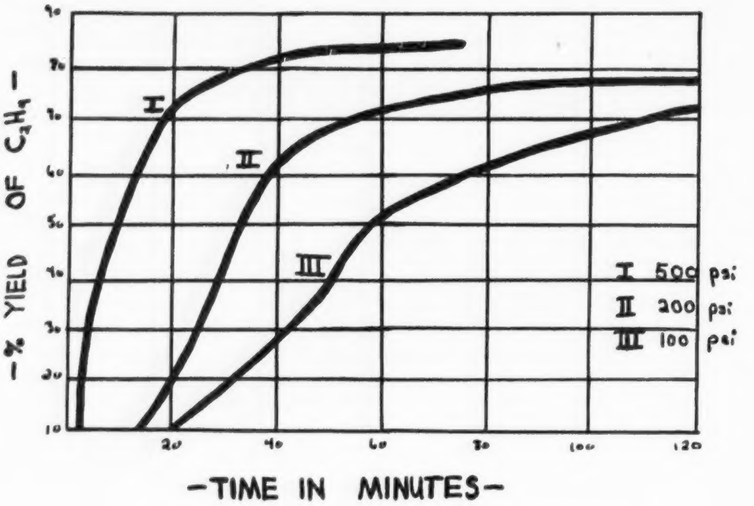
Another method is the direct oxidation of ethylene. The ethylene, of ninety-five per cent purity, is mixed with air to about three to five per cent concentration and passed over a catalyst of finely divided silver at 200-300C. The oxide is removed by absorption in water. About forty percent conversion is achieved.

$$2CH_2{=}CH_2 + O_2 \rightarrow 2\,\underbrace{CH_2-CH_2}_{O}$$

The demand for ethylene oxide has slackened recently and the selling price has leveled off at about seventeen cents a pound as compared with an estimated cost of production of ten to twelve cents a

**Flow sheet for synthesis of alcohol from ethylene.**






Yield of $C_2H_4$ as a function of time and pressure.

pound. It is feared that there may be an oversupply in the near future.

Ethylene glycol is made by the hydrolysis of ethylene oxide, catalyzed by a trace of sulfuric acid and heat.

$$\underset{\diagdown O \diagup}{CH_2—CH_2} + H_2O \rightarrow \underset{OH \quad OH}{CH_2—CH_2}$$

The acid is then neutralized, the water evaporated, and the glycol distilled off. The present selling price is about thirty cents a pound.

The normal amount of ethylene coming from the cracking towers is not sufficient to keep an alcohol plant running on a definite time-table. Adjustments must be made to increase the yields of ethylene. It has been found that six to fourteen per cent of the cracking charge consists of $C_3$ hydrocarbons or lower of which nine per cent is ethylene. Vapor-phase cracking can yield a gas containing twenty to twenty-five per cent ethylene, and even higher percentages may be obtained by cracking ethane-propane mixtures or the propane-butane cut of stabilizer gas. Additional ethylene may be gotten from operations designed for the production of butadiene and isoprene.

If the ethylene content is sufficiently high, saturated hydrocarbons such as methane and ethane need not be removed. However, to prevent excessive polymerization, the higher olefins should be removed with eighty-five per cent sulfuric acid or a hybrocarbon absorption oil.

**Hydration of Ethylene**

The direct hydration of ethylene involves the reaction

$$C_2H_4 + H_2O = C_2H_5OH +$$
10,964 cal per mole at 15°C.

It has been found that the formation of alcohol is favored by low temperatures and high pressures and a relatively high ratio of ethylene to water. The pressure cannot be increased indefinitely, however, since at lower temperatures a high pressure will condense the vapor causing an unfavorable change in equilibrium, and, at higher temperatures, it will cause polymerization of the ethylene.

Since this reaction is slow at low temperatures, a catalyst must be used. Aluminum oxide has been found to be most active, but many others can be used, such as oxides and phosphates of thorium, tungsten, and iron. No side reactions of importance have been found, except above 350°C where there is some polymerization.

Under optimum conditions the conversion is only twenty-five per cent so that re-cycling is necessary and a concentrated supply of ethylene must be used.

Despite the low yield there are several advantages to catalytic hydration. Since acid solutions are eliminated, no expensive corrosion-resistant equipment is necessary and investment costs are lower. This method of production is now being used by several plants, among them Shell Chemical and Texas Eastman.

With the sulfuric acid process using concentrated acid, a yield of about ninety per cent ethanol is realized. This method is the one in commercial use today. By treating ethylene with concentrated sulfuric acid, usually ninety-seven per cent, a miture of mono- and diethyl sulfate is formed:

$$C_2H_4 + H_2SO_4 \rightarrow C_2H_5HSO_4$$
$$C_2H_5HSO_4 + C_2H_4 \rightarrow (C_2H_5)_2SO_4$$

These are treated with water to give ethyl alcohol.

$$C_2H_5HSO_4 + H_2O \rightarrow C_2H_5OH + H_2SO_4$$
$$(C_2H_5)_2SO_4 + SH_2O \rightarrow 2C_2H_5OH + H_2SO_4$$

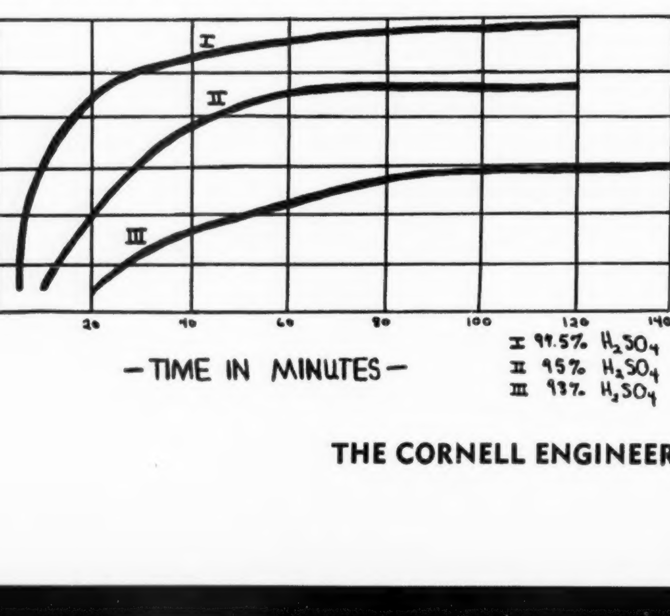
There is also some ether formed which must be removed.

$$C_2H_5OH + C_2H_5OH + HSO_4 \rightarrow (C_2H_5)_2O + H_2SO_4$$

Provisions must be made to reconcentrate the acid for further use, since it is diluted by the hydration process.

The absorption of ethylene in sulfuric acid is favored by high pressure (see cut) and high concentra-

Yield of $C_2H_4$ as a function of time and sulfuric acid concentration.



tion of acid (see cut). A catalyst of silver sulfate is most effective, but others have been used. Details of this process will be given later.

In order to avoid the costly and objectionable process of reconcentrating the sulfuric acid, a method has been developed whereby the formation of sulfates and subsequent hydrolysis is carried out in the same vessel in which the acid, of about eight per cent strength, in effect acts as a catalyst. High pressures and temperatures are required, but a yield of ninety percent is claimed. Thus, ethylene and steam would be bubbled at six hundred to one thousand psi and 250°C through dilute sulfuric acid in a vessel packed with Raschig rings.

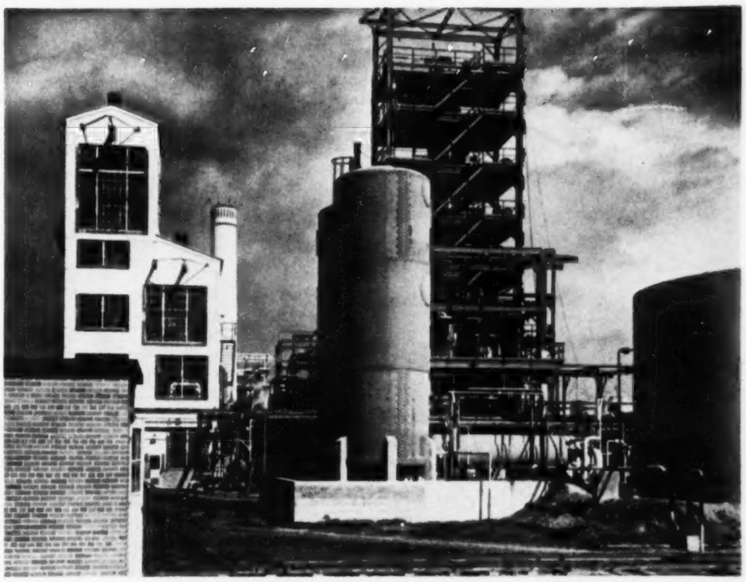
Disadvantages of this process using dilute sulfuric acid include several corrosion problems encountered in handling eight per cent sulfuric acid at 250°C, and special equipment required by the high operating pressure. This method is not operated commercially.

The flow diagram illustrates a typical set-up of the concentrated sulfuric acid process and reference should be made to it.

Ethylene, at a concentration of thirty-two one hundreths per cent and a pressure of two hundred to five hundred psi, depending on the ethylene concentration, is absorbed in ninety-seven per cent sulfuric acid at a temperature of 180°F in an absorbing tower. Two pounds of acid are needed per pound of alcohol produced. Because the reaction is exothermic, internal cooling coils must be used to maintain this temperature. Waste gases from the top of the tower, after being scrubbed with caustic, may be used as fuel.

The liquid product containing mixed ethyl sulfates is then mixed with water and sent to the hydrolyzer. This reaction takes place at elevated temperatures to vaporize the alcohol and reduce ether formation. From here it goes to the stripping tower where steam is used to strip out alcohol and ether and permit them to pass out the top while the acid solution flows from the bottom to be reconcentrated.

The alcohol-ether vapor is scrubbed with caustic to remove any trace of acid which may have been



Baton Rouge, Louisiana, alcohol plant.
—Standard Oil Co. of N. J.

carried over from the stripper. It is then condensed and sent to the ether column where low pressure steam is introduced to vaporize the ether. The ether is backwashed at the top of the column to remove the last traces of alcohol, and it is then condensed and sent to storage.

The alcohol-water solution passes into a fractionating tower where the alcohol is evaporated off under high reflux and condensed as alcohol of about one hundred ninety proof (ninety-five to ninety-six per cent by volume). Water is piped from the bottom to be used again, and fusel oils are taken from an intermediate point on the tower.

After being condensed, the alcohol is sent to weighing tanks where a weighed amount of denaturant is added. The purpose of denaturing is to make it unfit for human consumption so that it may be sold tax-free for industrial use. The denaturant added depends upon the use of alcohol and a great many varieties are shown. Common ones include methyl alcohol, benzene, gasoline, brucine, and acetaldehyde.

### Reconcentration of Acid

The sulfuric acid, as it comes from the stripping tower, has a concentration of about fifty per cent and must be recouncentrated to ninety-seven and one-half per cent before it can be used again. This can be done as follows: First, the acid is concentrated to seventy per cent in an acid reboiler and the steam is returned to the stripper. The acid passes to a Simonson-Mantuis two-stage vacuum system which concentrates the acid without causing objectionable fumes. In the first concentrator the acid is brought up to eighty-nine per cent under 2.5 psi; in the second it is brought up to the desired concentration at 0.4 psi.

Because of the low pressures used, the acid temperature is kept below 370F. Since steam at this temperature would require a high pressure, Dowtherm "A" vapor (diphenyl and diphenyl oxide) is used, which gives a temperature of 575°F at 20 psi.

### Costs of Production

By law no synthetic alcohol can be used for internal consumption. Even though there is no chemical difference, drinking alcohol must be fermented from grain.

The cost of producing synthetic alcohol is relatively low compared to fermentation alcohol. One gallon of synthetic alcohol can usually be sold for less than the price of the molasses or grain required to ferment one gallon of fermentation alcohol.

(Continued on page 38)

# Inorganic Paint Pigments

By FELIX ROSENGARTEN, ChemE '57

*Illustrations courtesy of E. I. du Pont de Nemours & Co.*

Paints have generally been defined as fluid compositions which contain solid particles in suspension and which are used both as decorative and protective coatings on the surfaces to which they are applied.

Paint is made by grinding the solid particles, known as pigments, in an oil or varnish medium to an extremely fine state of sub-division; then small proportions of a volatile "thinner," such as turpentine, are added to make an easier and more uniform spread. Sometimes still other surface-active compounds for more specific purposes are added also. The paint medium or vehicle commonly used is composed of a mixture of raw and boiled linseed oil.

When paints are applied the volatile medium evaporates, leaving behind an oil pigment coating, which dries or hardens owing to the absorption of oxygen from the air by the oil contained. The solidified oil acts as a binder for the pigments and holds them in their place.

The basic properties of a paint are determined by the pigment-vehicle relationship, for a paint must be able to stand up under wear from many causes. If there is continued and destructive oxidation of the vehicle after the paint has dried, a progressive powdering will result which is known as "chalking." "Peeling" is caused by poor attachment of the paint to the surface, and "flaking" comes about when small sections of paint drop from the surface because of dirt or grease behind the paint.

The "hiding" or "covering" power, stemming directly from the above relationship, is the difference in the refractive indices of the pigment and the vehicle. In the case of dry pigments, air may be considered to be the vehicle. Since air has an index of refraction much lower than any of the paint liquids, a layer of dry pigment has a relatively high hiding power.

From this relationship of pigment to vehicle the pigments can also be divided into three main classes: 1) inert, 2) basic, and 3) soluble pigments. Paints made with inert pigments should be based on vehicles which are as permeable as possible to water and to salts. Examples of this are lead, zinc, barium, calcium, and strontium linoleates, which are all inert in water. When basic pigments are used for protection against atmospheric exposure, soap formations or the neutralization of the oils with the organic bases should be encouraged by the use of linseed oil or a similar oil and should be controlled by means of a suitable pigment mixture. In the presence of a salt the vehicle should be alkali resistant. Zinc chromate and zinc tetroxychromate are both soluble pigments which render water non-corrosive, probably because of chromate ions; however, when ground in drying oils, they may function as basic pigments and form soaps. The pigment-vehicle relationship will then depend mainly on the properties of the specific pigments used.

**Temperature control of slurry in vat—part of paint manufacturing process.**


### Pigment Texture

The texture of pigments refers to the relative hardness and the shape of the individual particles, rather than the degree of subdivision. A

pigment may be finely divided and hard or soft; it may be flaky or needle-shaped. Whether the film is a paint or an enamel is determined by the texture of the pigment, the former being rough and hard, the latter smooth and soft. Usually, a pigment of soft texture will disperse much more readily, grind better, produce a better finish, have less tendency to settle and harden, and will make a better flowing and spreading paint than one of hard texture. All this is very essential to the manufacture of paints, since aging and gradual flocculation may change a once good pigment texture to a poor one.

Of importance to the texture is the density, which is the mass of a given volume of loose, dry pigment. Two common methods for measuring this are the Scott Volumeter, which weighs a mass of pigment contained in a one cubic inch receiver, and the Becker-Rosenmuller method, which is much more complicated and will not be discussed here. The higher the density of a pigment, the less oil it will absorb. The average pigment absorption ranges from about 10 to 100 milliliters of oil per 100 grams. If one correlates facts concerning the nature of the medium, the state of the pigment surface, its moisture, etc., one can calculate fairly accurately a measure of the oil required to fill the spaces not occupied by the pigment particles.

The color of the pigment is, of course, important too, for this is what appeals to our esthetic senses. It is possible to predict the color of a paint from various laws governing the optical properties of pigments. The most common of these is probably that of Amy and Neugebauer, according to which the optical properties may be expressed in terms of two constants: the coefficient of absorption (alpha) and the coefficient of diffusion (delta).

In order to predict the color of a paint, it is first necessary to determine from the pigments present the relative values of the constants alpha and delta for a number of different wave lengths scattered throughout the visible spectrum, then to substitute the figures in the appropriate expression to give the predicted reflection of each wave length, and, hence, to construct a reflectance/wave length curve, from which the color, by more complex analysis, can readily be calculated. The values of these coefficients will vary from medium to medium with refractive index.

**Pigment being dumped from a filter press during paint manufacture.**

### White Pigments

Probably the oldest and the most important of the white pigments is white lead, $2PbCO_3 \cdot Pb(OH)_2$. Its paint can be applied quite easily and has a high hiding power. However, one disadvantage is the darkening reaction with sulfides present in the air. This has been overcome for the most part by the addition of zinc oxide or pigment extenders such as barium sulfates and barytes. Next came basic lead sulfate with the approximate formula, $2PbSO_4 \cdot PbO$. It has similar properties to white lead but is usually mixed with other pigments and offers much more resistance to the action of sulfur. Both these lead pigments offer the threat of lead poisoning, and even though much has been done to replace them, they are still widely used. Sometimes they are reacted with vegetable oils to form soaps, improving the paint property.

Zinc oxide is a more recent pigment, but it does not have the hiding power of white lead; it forms paints of only intermediate opacity. However, ZnO is one of the whitest pigments we have, since its color is unaffected by atmospheric gases. Zinc oxide prevents premature chalking because of the forming of sinc soaps and its high opacity toward ultraviolet rays.

Since it will react with its vehicle to form a very hard film, it is combined with other pigments, a much used mixture being 65% lead and 35% zinc oxide.

Lithopone is a pigment consisting of barium sulfate and not less than 26% of zinc sulfide. It is very opaque, because the zinc sulfide has a very high refractive index, 2.37. However, heating it to very high temperatures and then quickly submerging it in water removes this effect. Today it is one of our most economical white pigments, and it is sold extensively. It is a very fine pigment with a clear white color, and its hiding power is even better than that of zinc oxide. Lithopone is especially well adapted to white and tinted interior paints, since it will combine readily with a variety of vehicles.

Titanium dioxide is the newest of the important white paint pigments. Titanium dioxide is manufactured in two crystalline forms, rutile and anatase, both of which have very high refractive indices, 2.72 and 2.55 respectively. Rutile has a covering power which is about 30% greater than that of anatase. The commercial pigment is a fine white powder. Since it is so bright and has such a high covering power, titanium dioxide is usually sold mixed with barium sulfate, anhydrous calcium sulfate, or magnesium silates in the ratio of three to seven. Titanium dioxide is also non-poisonous. The anatase modification chalks rather badly when used as an exterior paint, but rutile $TiO_2$ is fairly inert chemically.

Lump color in drying trays and barrels.

Other common white pigments of importance are lead titanate, titanated lithopone, zinc, barium, or calcium sulfide, and zinc magnesium sulfide. Antimony oxide is used in enamels, often combined with other pigments in fireproofing paints and coatings.

Recent tests by the Zinc Pigment Development Association in England have shown that a pigment mixture of 60% zinc oxide and 40% rutile titanium dioxide holds up much better against outdoor weather than almost any other zinc paint pigment.

### Other Colors

The most widely used blue pigments today are cobalt blues, iron blues, and synthetic ultramarine blue. Cobalt blues are very expensive and are not used too extensively for ordinary purposes. A compound of cobalt oxide, $Co_3O_4$, and alumina, $Al_2O_3$, is the most common cobalt blue on the market. Iron glues consist of the many ferric ferrocyanide blue compounds. Iron blue pigments have good coloring power and are unaffected by light and air. They are fairly stable towards acids but can be decomposed by alkalis. Ultramarine blue is a complex sodium aluminum silicate and sulfide. The blue can be made darker by using different sodium compounds in the preparation of the pigment. These pigments have low covering power but are stable toward alkalis. They react with acids, liberating hydrogen sulfide. Another blue pigment which is being used more and more widely, especially in printing, and which is very stable towards chemicals, heat, and light, is one prepared by treating phthalonitrile, an organic substance, with copper.

The oldest yellow pigment is ocher, a natural pigment, but due to its very weak tinting colors it is gradually being replaced in importance by chrome yellows. These are our most popular yellow pigments today; they are very brilliant and very opaque. Zinc chromates, although of poor tinting power, are widely used for their inhibiting effect both in mixed paints and as a priming coat for steel and aluminum. Litharge, PbO, is another yellow pigment which is often used in anti-corrosion paints and as a drier.

Red lead, $Pb_3O_4$, is a brillant red-orange pigment which combines with its linseed oil vehicle to form a tough, elastic, and very adherent film. Because of its corrosion-resistant properties, it has found extensive use as a paint primer for iron and steel surfaces. $Fe_2O_3$, ferric oxide, is another paint pigment which finds its main use as a primer. Venetian red is a mixture of ferric oxide with an equal volume of calcium sulfate as the pigment extender; it is quite permanent and stable, especially on wood. Indian red is a natural pigment whose ferric oxide content is 80 to 95%. The basic lead chromate and cadmium reds are also used as red pigments. Comparing red lead paints with iron oxide paints shows that with respect to time the former has an increase in tensile strength and a decrease in elongation at break. The latter paint shows a decrease in tensile strength and an increase in elongation at break, Composites of both have beeen found which give the intermediate behavior.

The best permanent green pigment known is chromium oxide, $Cr_2O_3$. Although it is expensive and lacks brilliance and opaqueness, it is very stable thermally, shows infra-red reflectance and permanency toward light. Chrome green, the only other green pigment of any importance, is only a mixture of iron blue and chrome yellow. If properly mixed this pigment is very brilliant and has a high hiding power.

Carbon black, graphite, and lamp black are our chief black pigments. Carbon black gives a surface of low reflectance to a paint. Lamp blacks are used for tinting purposes, and graphite is used mainly in corrosion-resistant paints.

# Brain Teasers For November

Short on cash? Well, go no further, the answer to your problem may lie on this page. All you have to do is find the correct answers to all the three simple puzzles below. Then mail your solutions to The Cornell Engineer, and if your solutions are the first to arrive, you will receive three crisp one dollar bills. That's all there is to it. Sounds simple, doesn't it? The puzzles do not involve higher calculus or even lower calculus. As a matter of fact, the first two could be solved by a high school freshman with a knowledge of just elementary algebra.

1. The combined age of a man and his wife is six times that of their children. Two years ago their combined age was ten times that of their children, and six years hence it will be three times that of their children. How many children have they?
2. A rectangular piece of paper 5x12 in. is folded over and creased so that one pair of diagonally opposite corners meet. What is the length of the crease in inches?
3. Two regular decks of playing cards rest side by side on a table. I turn over the top card of each deck. If they coincide exactly—that is, if both are the ace of spades or the deuce of clubs or the four of hearts, etc.—I win. If they do not coincide, I turn over the new top card of each deck and compare them. Again if they coincide I win, and if they do not, I turn over the new top card of each deck. I keep on repeating this same procedure for the next fifty cards. If after going through both decks, I still have not simultaneously turned up two cards that are identical, I lose. What is the probability that I win?

**WE'RE SORRY your October ENGINEER was delayed more than a month by a press breakdown.**

# Metal Ceramic Composites

By JOHN SCHMUTZ, ChemE '55

Recent research has revealed metal ceramic composites as a promising new material of construction. The materials, commonly known in industry as cermets, ceramals, metamics or cemented carbides, are a combination of metals, with their characteristic luster and high electrical and thermal conductivity, with non-metallic materials of high melting points, and limited or negligible ductility at room temperatures. Many of us have seen such materials in the form of ornamental vases or perhaps in the form of tungsten carbide-cobalt tool bits; but in recent years their use has been contemplated in many new and broader fields, especially in high temperature applications.

As a high temperature material of construction in such things as gas turbines, rocket engines, and other high temperature power plants, metal-ceramic composites show great promise. For such applications a material must possess: (1) high creep resistance, (2) resistance to thermal and mechanical shock, (3) high strength to weight ratio, and (4) resistance to oxidation. Ceramics do possess in general good high temperature strength, creep resistance, and, in the case of oxides, good oxidation resistance; but they have rather poor thermal shock resistance. By the addition of certain metals to form a composite, the high temperature strength of the ceramic is decreased but the thermal shock resistance is markedly increased. The overall effect is to increase the safe operating temperatures of equipment.

This field of metal ceramics is as yet very new. One of the first metal ceramics developed was a combination of aluminum oxide and iron. This combination was developed in Germany during World War II as a substitute for high temperature alloys. Here iron decreased the high temperature strength and the oxidation resistance compared to pure alumina but produced a large increase in thermal shock resistance. The tensile strength of this material at 2200 F is approximately 10,000 psi. A combination of 70% alumnia and 30% chromium developed recently at Ohio State University has even more promise as a high temperature material of construction. The disadvantage of these high creep and oxidation resistant metal oxide combinations is there extreme brittleness. In an effort to eliminate this brittleness and retain or improve other desirable qualities, combinations of metals with carbides, nitrides, and borides have been developed.

The following table compares the high temperature properties of several class of ceramals with those of metals.

Electro Metal Corporation has conducted tests on chromium boride sintered with nickel, nickel copper, nickel chromium, and cobalt. In modulus of rupture tests, a chromium boride-15% nickel composite proved the best with a strength at room temperature of 123,000 psi. Stress rupture tests were carried out at 1500 F and 1600 F for a 100 hour life, with stresses of approximately 4500 and 2500 psi, respectively. Unfortunately, oxidation tests showed that this material is limited to temperatures below 1750 F due to the formation of a liquid phase at higher temperatures. This formation of less refractory borides during exposure to elevated temperatures probably influenced stress rupture strengths at 1500 F and 1600 F. Kennemetal Inc. has developed a composite of 20% cobalt and 80% titanium carbide (K-138). Oxidation resistance of this composite can be markedly improved by minor additions of tantalum carbide or columbium carbide and tantalum carbide in the form of a three carbide solid solution. Small turbine blades of this composite have been operated under the conditions simulated in gas turbines. This composite shows promise as a material for blade construction for temperatures up to 1500 F.

| Material | Refractoriness | High Temp. Strength | Ductility | Thermal Shock Resistance | Stability | Oxid Res. |
|---|---|---|---|---|---|---|
| Metals | Poor | Poor | Good | Excellent | Good | Poor |
| Oxides | Good | Good | Poor | Poor | Excellent | Excellent |
| Carbides | Excellent | Excellent | Poor | Fair | Excellent | Poor |
| Borides | Excellent | ? | Poor | Fair | Excellent | Fair |
| Nitrides | Good | ? | Poor | Fair | Fair | Fair |
| Silicides | Fair | ? | Poor | Fair | Fair | Good |
| Sulfides | Good | ? | Poor | ? | Good | Poor |
| Phosphides | Fair | ? | Poor | ? | Fair | Poor |

### Used as Magnetic Core

Besides their high temperature applications, metal ceramic composites can be used in the magnetic cores of self-induction coils for high frequency communication equipment. These cores cannot be made of solid magnetic materials because of extremely high eddy current losses at high frequencies. If the magnetic material is reduced to very fine particles and insulated with a ceramic the eddy current loss is reduced to a very small value. In addition, such a composite gives an improved magnetic permeability over a wide range of flux density, reduction of hystersis losses, and modulation of hysteresis effects. The requirements of the ceramic

coating are that it be thin (about .5 microns), and capable of withstanding subsequent heat treatment. To make the magnetic core, a few thousandths of one percent of sulfur is added to an inherently malleable iron-nickel-molybdenum alloy. The sulfur forms a network of microscopic sulfide films at the grain boundaries of the metal. At high temperatures this metal can be hot rolled to small section but at lower temperatures the sulfur makes it very brittle and the metal can easily be fractured by tapping. The metal is thus hot-rolled, cooled, ulverized in an attrition mill to very fine equiaxed crystals , which are annealed, insulated with metal oxide ceramic complex, and again annealed.

Current collector brushes of electrical machinery are examples of laminated structures in metal ceramic composites. Such brushes must have low friction, high wear resistance and high electrical and thermal conductivity. Since pure carbon brushes have proved unsatisfactory for low-voltage and high-current applications, metal graphite composites were developed in which the metal phase provided high current carrying capacity and the graphite served as a solid lubricant. The laminated form provides a lower electrical resistance parallel to the direction of the current flow than perpendicular to it. These laminated structures are produced by pressing a mixture of flaked powders of silver or copper and the powdered graphite. The mixture is pressed in a direction perpendicular to the current flow in the brush.

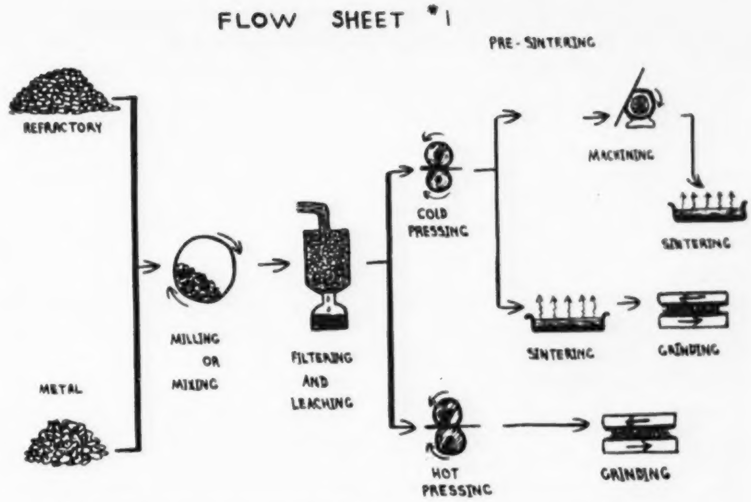



*Fig.* 1. **Hot and cold pressing techniques in production of metal ceramics.**

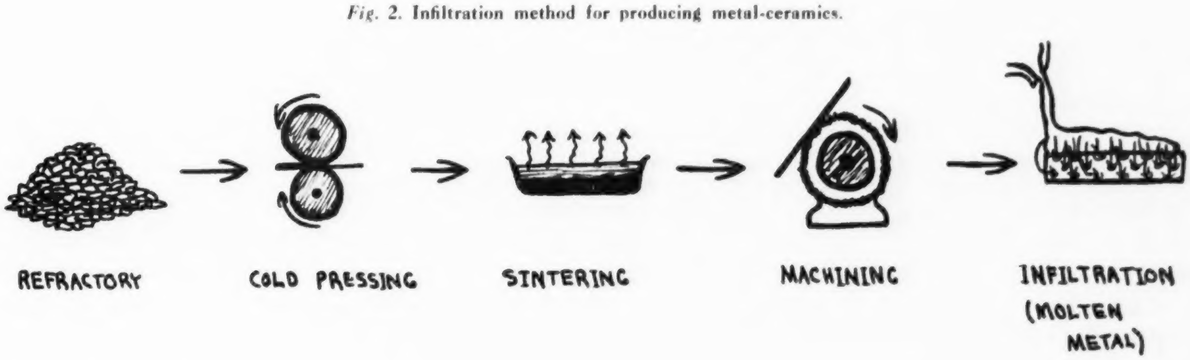
**Bonding**

Since in metal ceramic composites true dissimilar materials are being combined, the problem of bonding becomes of prime importance. Although as yet unverified, several hypotheses of the nature of this bonding have been proposed, One of these hypotheses is that of mutual solubility. This may be a limited solubility of one of the components in the other as in the case of cobalt cemented carbides, or, as in chromium cemented alumina composites, a solubility (in the ceramic components) of a surface phase of the metallic component. In the case of alumina and chromium the bond is due to the formation of a $Cr_2O_3$ film on the chromium during firing. Since this film is isomorphous with alumina, it readily dissolves in the alumina, forming the bond. The rate of formation of this oxide film, which is critical to the strength of the bond, is a function of the time, temperature, and the atmosphere of firing.

Another type of bond is due to a chemical reaction between the metal and the ceramic, or between the ceramic and the film formed on the metal. In the case of the iron-alumina composite this is a spinel, $FeO \cdot Al_2O_3$. In still other cases the bonding may be primarily mechanical with little or no solubility of the components. This is the case of the silver-graphite collector brushes mentioned previously.

Finally, bonding may be accomplished by the addition of a minor amount of a third component. This additive may bind the metal and the ceramic by solution, by reaction with the components, or by both. An example of this type of

*Fig.* 2. **Infiltration method for producing metal-ceramics.**



bonding is the use of titanium hydride to bind metal and ceramic parts in electron tubes.

In addition to bonding, many other problems must be recognized in selecting materials for metal ceramic composites. First, the thermal expansion coefficients of the two materials must have the proper relation throughout the operating temperature range. This problem is particularly severe in metal ceramics because of the large temperature ranges usually involved, and because of the limited range of the coefficients in ceramics. A mismatch may mean highly strained fabricated objects or actual breakage. Another problem is to match sintering shrinkage. Chemical reaction between the components, accelerated by high fabrication and service temperatures, must also be considered. An example of this type of reaction might by the formation of a low melting eutectic phase.

### Design and Fabrication

Mechanical design is of prime importance in producing metal ceramics. Substitution of metal-ceramics for metals without changing the design of the objects may lead to serious difficulty. These difficulties arise principally because of the limited ductility of the composites. Ductility is important for resistance to impact, assembly and handling, and distribution of stresses in service. Dampening capacity and density must also be considered in metal ceramics. In the case of rotating objects, metal ceramics have a distinct advantage over metals because of their low density.

Some features which should be avoided in metal ceramic design are: (1) abrupt changes in thickness, (2) non-uniform cross sections, (3) sharp corners, and (4) internal angles without fillets. In addition it should be remembered that the compressive strength of metal ceramics is usually several times larger than its tensile strength.

Due to the high melting temperatures of the constituents, fabrication of metal ceramics is limited primarily to powder metallurgy processes. As shown in Fig. 1, for both the hot and cold pressing technics, both the metal and the ceramic are pulverized to particles, 325 mesh in size. These are then blended in a ball mill to the proper composition so that each ceramic particle is coated with a thin film of metal. In cold pressing, the composite is placed in hardened steel dies and pressed by hydraulic and mechanical presses at pressures of from 5 to 50 tons per square inch. The composite is then sintered at temperatures of 2500 F to 4000 F in electrical resistance or high frequency induction furnaces in the presence of protecting atmosphere. If considerable machining is required, presintering is used prior to machining. Grinding is used for final dimensioning. For short tubes and rods of uniform cross section, the metal and ceramic powders are mixed with an organic binder, such as wax, and extruded to attain the compact composite. The binder is volatilized in sintering.

Two methods are employed in hot pressing. One is to apply the full load of 500 to 2500 psi at room temperature, heat to the sintering temperature (2500 F to 4000 F), release the load, and cool. The other method is to heat to the sintering temperature, and then apply the load. A modification of these two methods is to apply the load at room temperature, heat to the sintering temperature, and maintain the load and temperature for a given period of time. The load is then released and the composite cooled. Hot pressing produces composites of uniform density and low porosity.

Fig. 2 shows the infiltration method of producing metal ceramics. This process involves sintering the ceramic powder to a porous mass, and then impregnating the ceramic with molten metal by capillary action. This process is applicable to materials that have widely different melting points and which do not dissolve, or react with each other appreciably. Heat is supplied through the graphite dies by an induction coil. Other methods, less important, are flame spraying, vapor deposition, and cataphoresis.

Much fundamental theory, practice, and application must yet be investigated before the entire scope of metal ceramics may be evaluated. Information about the chemical and mechanical behavior of composite particles, such as bonding and mechanical design for the composites, is lacking. Despite this lack of complete information, metal ceramics have come into their own as materials of construction and the groundwork is set for a broad extension of a new product in engineering materials.

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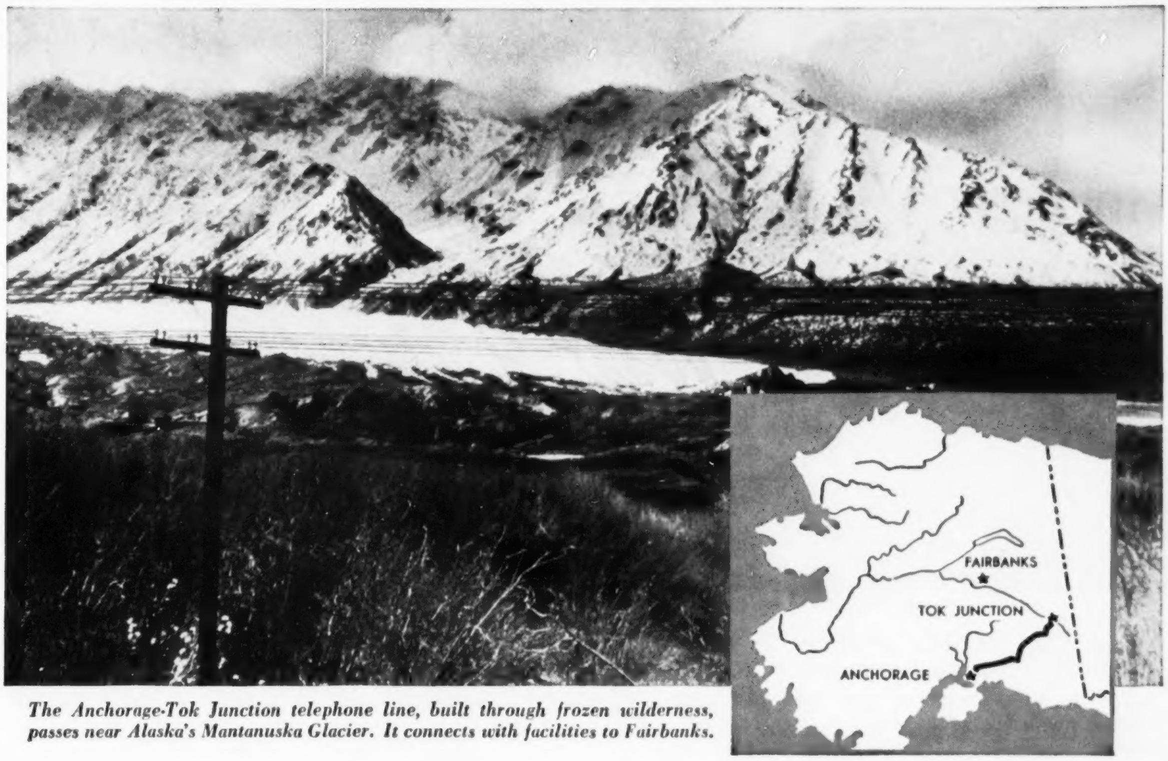



*The Anchorage-Tok Junction telephone line, built through frozen wilderness, passes near Alaska's Mantanuska Glacier. It connects with facilities to Fairbanks.*

# The line is through to Tok Junction, Alaska

**Ever hear of permafrost? It's sub-surface earth, permanently frozen hard as rock. But it was only one small problem in pushing through Alaska's newest telephone line**

As the nation's defense perimeter was pushed northward, it became plain that high-speed communications were needed for Alaska. The Army Signal Corps asked the Bell System to help build a modern telephone line for our strategic northern outpost. Today the line is a fact.

But the 330-mile route between Anchorage and Tok Junction on the Alcan Highway called for all the resourcefulness and skill of Bell System and Army engineers.

**What type of line?** Engineering studies and surveys proved that weather, expense and maintenance problems made it impractical for the new line to be aerial or buried cable or radio relay. The answer was open-wire pole line plus carrier equipment. But stringing this line through frozen wilderness was rough business.

The line had to cross two high mountain ranges. Average spacing between poles was 155 feet, but to bridge rivers, ravines and steep mountainside descents called for long-span crossings, ranging from 400 to 1800 feet.

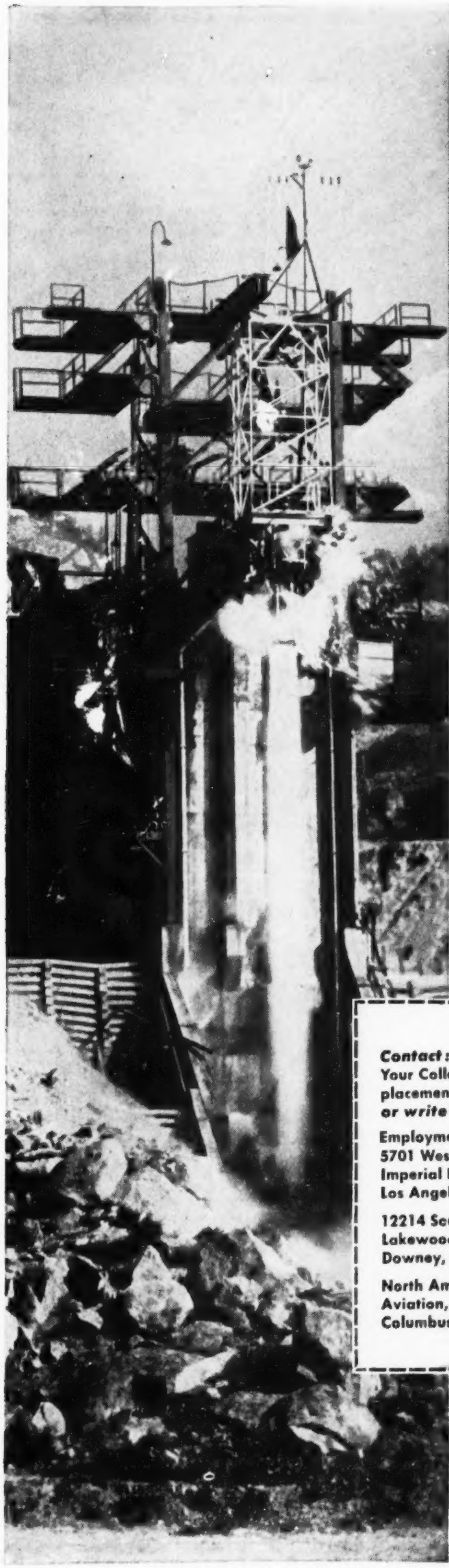
Getting the right vehicles, tools, and materials to the right places when needed was a major feat of planning in this wilderness. The line called for 15,000 poles of varying lengths, 2500 crossarms, 1,325,000 pounds of copper-steel wire and 2400 tons of hardware.

**Dynamite licks permafrost.** Bulldozers, pole-hole diggers and big trucks battled their way over tortuous mountain roads. The simple process of setting poles proved almost impossible in some areas because of a volcanic silt hardened by permafrost. No drill was tough enough to withstand its pumice-like action. The problem was licked by punching holes and using small dynamite charges.

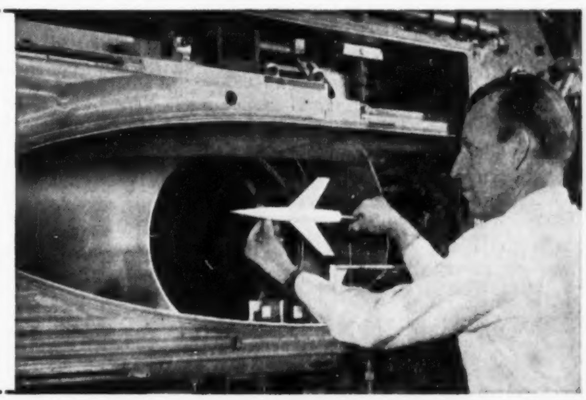
But now the work is done. Engineers have turned their talents to other parts of the vital communication system—building a long distance dial switching system between Anchorage and Fairbanks.

And so it is with the fast-growing telephone company. There always is a new frontier to conquer—in research, at the Bell Laboratories, in manufacturing at Western Electric, or in one of the operating companies serving the changing requirements of a constantly shifting population. Check now with your Placement Officer on the opportunities which await college engineers in the Bell System.

**BELL TELEPHONE SYSTEM**







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**Thomas W. Hopper**

*"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students and to establish closer relationship between the college and the alumni."*

The aims of the Cornell Society of Engineers are to promote the welfare of the College of Engineering, to provide a friendly interest and aid in the success of its graduates, and to foster a closer relationship between the College and its alumni.

How can the welfare of the College of Engineering be promoted? Here are some of the ways:

1. We tell our friends about Cornell and its many advantages.
2. We talk to school principles, teachers, and likely students about Cornell Engineering. We help them obtain catalog information, interviews, and campus visits.
3. We take an interest in the courses being taught in the Engineering College and where possible make contact with the faculty and undergraduates.
4. We serve on Scholarship Committees.
5. We respond to the best of our ability whenever the college expresss a need for financial and other types of help.

How may the interests of Cornell Engineers be advanced and a closer relationship fostered?

Through the many activities of the Society that produce intangible values in this respect.

Human nature being what it is, most of us want to be identified with a successful operation, to be a member of the winning team.

In our efforts to satisfy this desire, the success of the Engineering College and the success of its graduates are interwoven. Accomplishments of individual Cornell Engineers are reflected on the college, and conversely, acceptance of the College as a leading engineering institution adds stature to its graduates.

It is helpful to know who the outstanding Cornell Engineers are in your community and to publicize their achievements. If possible we want to have a speaking acquaintance and friendship with them. If there is a branch of the Society in the particular area, we want these men to be our speakers so that we can better understand their qualities of leadership and they in turn can appreciate our abilities and worth.

This approach furnishes a means for achieving solidarity as a group and provides a strong foundation on which to build an even greater Cornell Society of Engineers.

# ALUMNI ENGINEERS

**Edward J. Blair, M.E. '05,** retired last April, closing a forty-eight year career in the Chicago Transit Authority, where he became chief engineer and special engineer. He and Mrs. Blair now reside in Tryon, North Carolina.

**Vincent R. Stirling, C.E. '05,** is constructing pipelines across the Straits of Mackinack, Michigan, for Bechtel Corp. of Los Angeles, California. He lives at 5280 Castle Road, La Canada, California.

**Edgar MacNaughton, M.E. '11,** is a professor and the head of the Mechanical Engineering Department at the Tufts College Engineering School. He has been at Tufts since 1914, except for a year spent

*—Alumni News*

**Edgar MacNaughton**

as associate professor of mechanical engineering at the University of Illinois. He has done summer work at General Electric, Westinghouse, Timken Roller Bearing, United States Shoe Machinery and Boston Elevated. He has been chairman of the Boston Section of ASME.

**Howard L. Aller, M.E. '06,** has been elected chairman of the board of Texas Utilities Co., of which he was president. His address is 1056 Commerce Street, Dallas, Tex.

**George B. Cummings, B. Arch. '12,** was elected secretary of the American Institute of Architects at their annual convention in Seattle, Washington. He is a fellow of the Institute and lives at 79 Front Street, Binghamton.

**Charles R. Vose, M.E. '14,** is on an Explorer's Club—Museum of Natural History trip through the Congo with the world's authority on African birds, Dr. James P. Chapin. They have covered the country from Lake Tanganyka to Lake Edward and have met many of the Congo native chiefs.

**Frank W. Pierce, M.E. '16,** director of Standard Oil Company of New Jersey, is a member of the National Manpower Council established by the Ford Foundation at Columbia's graduate school of business in 1951. The Council's report was presented to President Eisenhower in May of this year.

**Reginald H. Keays, C.E. '95,** Jackson Heights, Long Island, visited his boyhood home in St. Thomas, Ontario, Canada in July. Keays was described a few years ago at an engineering function in New York City as "The Dean of Tunnel Engineers." He has built tunnels for more than half a century, including aqueducts in Athens, Greece, flood-control dams in Macedonia, the first tunnel under the Hudson River, connecting New Jersey and Manhattan, the Brooklyn-Battery Tunnel, and he was active in the construction of the oil pipeline from the Texas production fields to the Atlantic seaboard out of New York City. He lives at 77-12 Thirty-fifth Avenue in Jackson Heights.

**Donald W. Exner, E.E. '28,** supervisor in charge of electrical power system development at Boeing Airplane Co., is chairman of the AIEE subcommittee on aircraft electric power systems and a member of the subcommittee on aircraft electrical insulation. He now resides at 6236 Thirty-fourth Avenue, N.E., Seattle 5, Washington.

**Alfred L. Parme, C.E. '35,** received the Fuertes Graduate Medal of the School of Civil Engineering in June, 1953, for his work in preparing the manual of engineering practice, "Design of Cylindrical

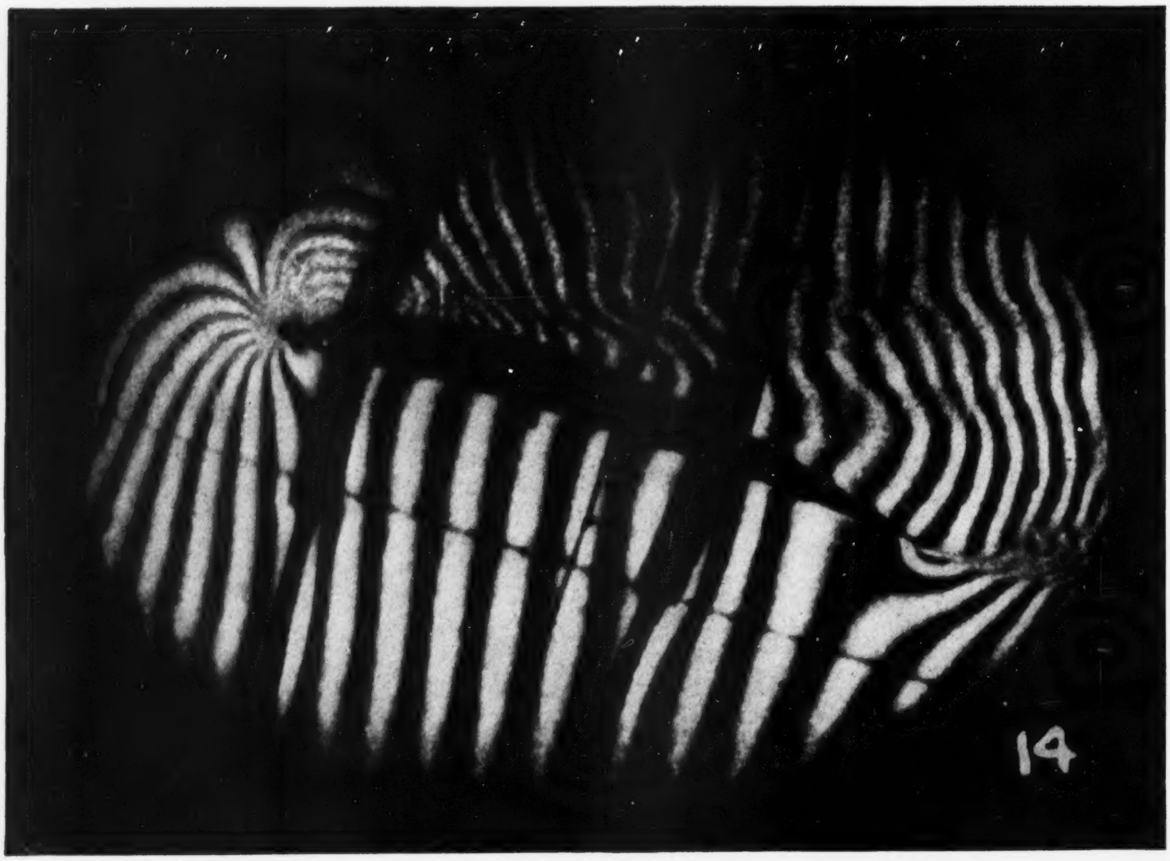
*—Alumni News*

**Alfred L. Parme**

Concrete Shell Roofs", published by ASCE in 1952. He is on the staff of the Structural and Railways Bureau of the Portland Cement Association in Chicago, and returned in March from work as a consulting engineer on the construction of the first arch dam attempted in Japan, on Kyushu Island. His address is 33 West Grand Street, Chicago, Illinois.

**Theodore H. Booth, M.E. '25,** of Woodland Drive, Lewiston, is Director of Manufacturing of the Carborundum Co., Niagara Falls, New York.

(Continued on page 33)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## Alumni Engineers

(Continued from page 29)

**John S. Fisher, E.E. '28,** has been president since 1948 of General Metals powder company, 130 Elinor Avenue, Akron 5, Ohio. The Company produces electrolytic powdered copper and compressed friction materials. John Fisher's address is 614 Vinita Avenue, Akron, 20, Ohio.

**Roland K. Blakeslee, C.E. '29,** of 145 Westford Circle, Springfield, Massachusetts, is product engineer of Diesel Fuel Injection Division, American Fosch Corporation. He is on the governing board of the South New England Section of the Society of Automotive Engineers.


**George H. Whitfield, M.E. '96,** pauses on the Quadrangle to chat with Dean S. C. Hollister of the College of Engineering after cycling 322 miles from his home in Washington, D. C., to attend the alumni reunions. Whitfield is 80 years old.



**Serge P. Petroff, B.Arch. '36,** is architectural consultant for tenant layout work in the Empire State Building, New York City. He opened his own office at 285 Madison Avenue last January. Previously, he was senior partner in the firm of Petroff and Clarkson.

**Byron E. Short, M.M.E. '36,** is chairman of the department of mechanical engineering at the University of Texas, Austin 12, Texas.

**Stanley R. Brodhead,, B.M.E. '42,** finished a twenty-one month recall to active duty as a major, U.S.A.F., last December, and became assistant to the director of engineering and contracts, Bridgeport-Lycoming Division of AVCO Manufacturing Corp. He and his wife and three children live at 700 Mill Plain Road, Fairfield, Connecticut.

**John A. Newman, B.C.E. '43,** has opened an office in the Gulf Building in Houston, Tex. As an independent consulting engineer, he is specializing in oil and gas field valuation and development. He lives at 3824 Belfontaine, Houston 25, Tex.

Simple enough now, this vertical ascent was history-making in 1939.

# COLLEGE NEWS

## A-C Network Calculator

The College of Engineering at Cornell University has announced the purchase of a major piece of equipment—an A-C network calculator from the Westinghouse Electric Corporation. This device is able to duplicate on miniature scale the complete power system of huge electric utilities servicing areas as large as entire states. By this means it can be applied to the solution of such problems as the location of new power plants and transmission lines for best service to particular areas. Solution of such problems by ordinary methods may take from three to six months because of the complex network of transmission lines and power stations in a large electric utility, but the calculator can handle these in less than a week.

The Cornell-Westinghouse calculator will be used for student instruction in electrical engineering and for research. It will be available also for development projects for electric utilities. The calculator will occupy a special laboratory in one of the new engineering buildings on the Cornell campus and will be in operation in about a year. This particular calculator has already been in use for two years by the Westinghouse Electric Corporation. Thus, Cornell will be able to use the calculator immediately, rather than first having to iron out any initial defects of the analyzer.

The need of network calculators has increased greatly in the last decade, paralleling the mushrooming growth of the power industry. In 1941 only twelve calculators were available in the country; the Cornell calculator will be the twenty-fifth to be installed.

## Student Lounge

The new student lounge in the basement of Sibley Dome is expected to be completed this fall. This lounge will be for the use of all engineering students. Serving as a place to relax between classes, the room will also provide a meeting place for undergraduate societies. It will contain a kitchen, coke room, and a large main room with excellent lighting and ventilation. The room will boast of all new furniture, new floor, and soundproof ceiling.

## Lankton Visits Japan

Gordon Lankton, fifth year mechanical engineering student at Cornell University, returned last September from a six-week conference series in Japan. He served as one of three American delegates selected by the National Student Association.

—*Cornell Daily Sun*

**Gordon Lankton**

The first three conferences were mainly on world affairs as they affect Japan and America. The last two conferences, attended by students from nine Asian countries as well as by Japanese and Americans, were of broader scope.

The International Student Association of Japan, a group of English-speaking Japanese students attending Japanese universities, sponsored the conferences, which took place in five different Japanese cities and were attended by a total of 600 people. The conferences have been held every year since 1934 except for the war years.

## Prize to Engineers

First prize in the A. F. Davis Undergraduate Welding Award Contest for 1952-53 was awarded to Roger C. Waugh and Otto P. Eberlein of the Class of 1954 in Metallurgical Engineering for their article on "Penetration Factors in Metallic Arc Welding," which was published in the May, 1953, issue of the Cornell Engineer. This award is made annually by the American Welding Society for the best article on welding or related topic that has appeared in any student engineering publication in an American university or college during the year. The award carries a cash prize of $200 to the authors and $200 to the journal of publication.

This is the second consecutive year in which first prize in this contest has gone to students in the course in Metallurgical Engineering at Cornell. The 1951-52 first prize was awarded to David Thomas and Paul Wisniewski of the Class of 1953.

## RCA Fellowship

Cornell's RCA Fellowship of $2,420 for graduate study in engineering physics has been awarded to William Y. Stevens, of South Portland, Me., who will enter the University's Graduate School this month.

The fellowship at Cornell was established in 1949 as part of a nation-wide program sponsored by the Radio Corporation of America. Recipients are recommended by the participating universities and chosen by the RCA Education Committee.

## ASEE Leaders

During the college year 1953-54, Cornell University will be represented among divisional officers and committee members of the American Society for Engineering Education by eight men.

Dean S. C. Hollister, ASEE president in 1951-52 and recipient of the society's Lamme award in 1952, serves on four major committees—society functions, financial policy, associate institutional membership and evaluation of engineering education. Prof. Dwight F. Gunder is also a member of the last-named committee.

Cornell has three divisional chairmanships. Prof. Arthur J. McNair heads the civil engineering division. Prof. N. A. Christensen heads the graduate studies division as well as serving on the committee for the promotion of ethical standards. Prof. Orval C. French chairs the agricultural engineering division and also represents it on the ASEE general council.

Prof. John C. Gebhard serves on the engineering economy committee, and Prof. Everett M. Strong is on the editorial board of the Teaching Aids Bulletin.

## Hollister Serves on U.S. Reorganization Commission

On July 25, Dean S. C. Hollister, head of the College of Engineering at Cornell University, was appointed to the new Government Reorganization Commission. The object of the group is to propose measures to save money and improve the efficiency of the various departments of the government by their reorganization or possible abolition. Besides inquiring into how efficiently a government activity is performed, this group, unlike the earlier Hoover Commission, has the authority to study whether the activity should be performed by the federal government at all. The law creating the new commission directed it to submit its final report not later than May 13, 1955.

In addition to the Government Reorganization Commission, Dean Hollister has been active in two other fields of public service in recent years. He has served on the Defense Department commission to draft defenses against atomic attack and has participated in studies designed to train more technicians and engineers.

## Shaw Studies Spectroscopy

Prof. R. William Shaw, chairman of the Department of Astronomy at Cornell, attended an Institute for Infrared Spectroscopy held at Fisk University, Nashville, Tenn., from Aug. 31 to Sept. 4.

Professor Shaw is interested in the application of infrared spectroscopic technics to the analysis of the composition of the moon's surface, a problem now under investigation in the Cornell Department of Astronomy.

## Alcohol

*(Continued from page 15)*

The price of ethylene from cracking operations is about five cents a pound. Manufacturing costs, including all fixed costs, labor, materials, depreciation, etc., are estimated at about ten cents a gallon of alcohol produced. Since it takes about four pounds of ethylene to make a gallon of alcohol, the total cost of producing a gallon of synthetic alcohol is thirty cents. The September, 1953, selling price for industrial alcohol was forty-eight cents a gallon, in carload lots.

The greatest deterrent to expansion of the synthetic alcohol industry is the high investment necessary for installation. Large quantities of expensive alloys are required to resist corrosion from the concentrated acid. Steel pressure vessels are needed with linings of lead, Karbate, glass, Duriron, and other similar materials. Facilities for producing ethylene and recovering the acid are costly.

The demand for industrial alcohol is increasing rapidly and most of it will have to be met with synthetic alcohol. It is estimated that sixty-five per cent of the alcohol produced this year will be manufactured synthetically.

The selling price of alcohol is determined largely by fermentation alcohol and is widely fluctuating. As recently as 1948 the price varied between seventeen cents and one dollar per gallon. Even so, the high price of molasses and grain relative to ethylene enables the synthetic product to consistently undersell the fermented. As a result, several former manufacturers of fermentation alcohol have discontinued production.

There are two other factors to be considered. First is the rising cost of ethylene due to the new uses which are being found for it and the consequent greater demand. Second is the catalytic synthesis of alcohol from water gas by the Fischer-Tropsch reaction. Although there is no commercial production by this method, it is generally felt by chemists that Fischer-Tropsch alcohol would be cheapest of all to produce.

# TECHNIBRIEFS

## Fire-retardant Paint

Engineers are studying with a great deal of interest the recent development of a new fire-retardant paint that is easily applied by brush or spray and actually stops fire from spreading. Everyone realizes the loss of life and property that results from rapidly spreading flame, so this may well prove to be one of the greatest advancements yet made to help prevent these disasters.

Every drop of this paint is claimed to contain a mass of minute "built-in" fire extinguishers; when exposed to flame the paint pours out carbon dioxide and calcium chloride, which smother the fire and retard the spread of flame right on the surface.

Developed and Manufactured by Morris Paint & Varnish Company of St. Louis, under license from the National Fire Retardant Corp., Fyr-Kote (this paint's trade name) is one of the few oil paints ever perfected to carry the Underwriters' label even though early patents on fire retardant paints go back to the year 1880.

Continuing studies and research of fire-retardant coatings are going ahead in pilot plant production because far more important than preventing property loss is savings in human life.

Fyr-Kote is an extremely washable flat wall paint, withstanding more than 25 cycles of scrubbing with strong washing powder and boiling water. It is easy to apply, economical, solid covering and long lasting.

## Plastic Bearings

Precision bearings capable of attaining speeds in excess of 100,000 rpm are now possible through the use of thermosetting laminated plastics. These easy-to-machine, light-in-weight materials possess a unique combination of properties which make them ideal as bearing retainers for high-speed applications.

As manufactured and fabricated by Synthane Corporation, Oaks, Pa., retainers for machine tools, grinding spindles, turbine and supercharged blowers, and aircraft instruments can be machined within the tolerances required for precision and super-precision bearings.

The comparative light weight of laminated plastics provide bearing designers with a number of advantages over metals. Due to the smaller masses involved, centrifugal forces resulting from extremely high speeds are reduced. As a consequence, there is less friction and wear against adjacent metal surfaces. Starting torques are lower and more consistent. The overall bearing weight is reduced, and galling, which is a temporary sticking or binding between two metal surfaces, is eliminated. This is particularly important where a fast, smooth acceleration is required. Galling is usually attributed to insufficient lubrication or drainage of lubricant away from the sliding surfaces. Laminates, while virtually impervious to oils and greases, do absorb small quantities of lubricant in the cotton fibers exposed during machining, and this endows the bearing with self-lubricating characteristics. Tests have shown that laminates run more quietly and with less vibration than steel at higher speed ranges.

## Transistor Production

The General Electric Company recently began production of new junction transistors which will provide essentially infinite life for many electronic devices.

These transistors use a crystal of germanium to perform many of the functions of much larger and more complicated electron tubes. They are now being applied to circuits under development for radar, airborne computing equipment, carrier current and two-way radio equipment, and television broadcasting equipment.

In a novel exhibit, the transistor was operated as the heart of a

(Continued on page 43)

## Technibriefs

(*Continued from page* 41)

minature radio transmitter while frozen in a cake of ice, which was then melted and turned into boiling water. Purpose of the all-weather exhibit is to illustrate the transistor's ability to perform efficiently under extreme variations in temperature and humidity. The new transistors also allow power ratings up to three times those of any previous transistors.

The new units are evacuated, hermetically-sealed, and they have unusual construction. They are the first to feature all-welded metal construction, which eliminates the aging effects of moisture and trapped solder flux fumes.

Previous methods of construction have failed to produce a transistor whose operating characteristics will not deteriorate with age, as a result of contamination either sealed into, or allowed to enter the casing.

The new transistors will be produced at the company's germanium production plant at Clyde, N. Y., at a rate of several million yearly.

## Crash-Proof Tape Recorder

A compact fire- and crash-proof airborne tape recorder designed to log everything that happens during an airplane or missile flight has been announced by North American Aviation, Inc.

Using tiny miniature electronic parts, the small recorder originally was designed to "go along for the ride" on U. S. Air Force guided missiles to report on altitude, speed, and general conduct of the vehicle in flight.

Carried by commercial, military, or private airplanes, the airborne tape can record important information during a flight as long as 10 hours. The tape can be run for another 10 hours non-stop with the previous information being "wiped off" as the new information is recorded. Over 500 hours running time can be racked up on the recorder before it needs a service check.

Locked in a sealed, crash-proof case, a 1,200 foot magnetic tape carries the log of a complete trip, including conversation in the cockpit, communications from the ground, data on pressure, altitude, time elapse, vertical acceleration, air speed, and direction. A quick check of the tape following an unexpected incident during flight would give engineers a full report of everything that happened in the airplane from take-off to the time of landing.

The 18-pound unit is about the size of a portable typewriter.

## Nuclear Research

Research with the Brookhaven Cosmotron has produced clear evidence for the production of neutral V-particles, according to a report by four scientists at Brookhaven National Laboratory, Upton, N. Y.: Drs. W. B. Fowler, R. P. Shutt, A. M. Thorndike, and W. L. Whittemore.

In 1947 Drs. G. D. Rochester and C. C. Butler of the University of Manchester, England, became the first scientists to discover these unusual V-shaped tracks. They found the tracks in a magnet cloud chamber exposed to powerful cosmic rays. Various research workers in Europe and America subsequently determined that the tracks are made by disintegration of unstable neutral particles forming protons and mesons, components of the nucleus or heart of the atom.

Before the observations at Brookhaven were made, a search for neutral V-particles had been carried out at the University of Chicago synchrocyclotron, the highest energy machine previously available. The results were inconclusive, although some events were recorded in photographic emulsions that may have been decays of neutral V-particles.

At Brookhaven, an average of one nuclear event involving a neutral V-particle is found for each 2000 photographs taken of two-billion-volt neutrons passing through atoms of hydrogen in a cloud chamber.


—*Donna Crook*

Many hundreds of V-particle decay events have been recorded in cosmic rays, but their nature is still somewhat uncertain. The characteristic inverted V-shaped tracks observed in cloud chambers represent the decay in flight of energetic unstable particles. Some involve the decay of a neutral V-particle to form two charged particle, while some represent the decay of a charged particle, a positive V, or a negative V, to give one charged and one or more neutral secondaries.

The neutral V's are the more common. In some cases the decay products of a neutral V are a proton and a negative pi meson, plus 37 million electron volts of excess energy. In some cases the products are a positive meson, a negative meson and 214 million electron volts of excess energy. Still different products probably result occasionally. Thus there are at least two kinds of neutral V's. Much less is known about the rarer positive and negative V's, but there are probably two or more kinds of them as well.

## News of Analog Computer

Boeing Airplane Company now can provide a lot of help for many difficult problems with its electronic analog computer, a fantastic assembly of vacuum tubes and circuits which, if given all the facts and figures, can provide the answers.

Boeing engineers and mathematicians make haste to point out, however, that their computer is not an electronic "brain." It cannot create. But if given the differential equations of a problem through its dials and wiring hookups, it can provide the answer with alacrity. It does this within its electronic circuits, regulating voltages so that they simulate the variables inherent in the problem.

The computer, standing almost seven feet tall, measuring about two feet wide and one and one-half feet deep, physically resembles an upended telephone switchboard. The computer has been used to solve numerous problems in industrial and college research, and has brought about considerable savings in material, man-hours and dollars.

A case in point was provided during the reconditioning of an escort-type aircraft carrier at the Puget Sound Naval Shipyard in Bremerton, Wash. Two electric generators had been replaced with a single higher-capacity generator, but when started the new unit was found to have vibrations, severe enough when the ship was docked, but more objectionable when the carrier put to sea and accelerated.

Engineers at the shipyard came up with several structural-change ideas, one of which called for alternating the dimensions and rigidities of the existing structure supporting the generator and then observing the effects. Instead of actually cutting into the ship's steel, however, the situation was simulated on a Boeing computer, and 16 modifications were tried out in five hours without touching a torch to the floor plates. One was found to reduce the vibration by 47 per cent and was selected as the answer.


● Claud M. Kellett, Jr. received his Bachelor of Electrical Engineering degree from Georgia Tech in 1950.

Claud's first year at Allison was spent in the company of other recent engineering graduates in a college graduate training program. This program helped him gain practical experience in the activities of selected departments throughout the Allison plants. On the completion of his training, a call to active duty with the Army delayed Claud's permanent assignment to an Allison department. However, the twenty-one months he was away did not diminish his opportunities in the least. When he returned early this year he was able to resume his career in engineering with the result that today he is an experimental engineer concerned with electronic instrumentation in the Research Group of the Transmission Test Department.

The torqmatic converter turbine that Claud is working with is a vital element in the operation of Allison heavy duty transmissions. Allison is the world's largest manufacturer of torqmatic drives for heavy duty Ordnance and commercial vehicles and equipment. The commercial converters and transmissions are used in scrapers, tractors, trucks, cranes, shovels and drilling rigs.

The problem presented to him in connection with the turbine was to find the level of residual stresses created in the turbine by repair welding performed on the hub. The feasibility of such welds might then be determined. Claud applied variable resistance type strain gages to the turbine vanes at their exits and read their strain levels with the strain indicator. Then he cut the vanes around each of the strain gages to relieve residual stress and re-read the strain levels. From the difference in strain between the stressed and relieved conditions he was able to calculate the residual stress induced by the welds.

Yesterday Claud was interested in torsional vibration and the electronic "know-how" required to present it for oscillographic recording. He knows that tomorrow the many tests of transmissions and component parts will each present unique problems. Pressure transducers, vibration pick-ups electronic flow meters and tachometers must be installed with a myriad of complicating factors ever present. Equipment not available must be designed and built, or existing equipment modified. A future at Allison holds a constant challenge of doing that which has not been done before.

*Allison is looking for young men with degrees in* MECHANICAL ENGINEERING, ELECTRICAL ENGINEERING, AERONAUTICAL ENGINEERING *and* INDUSTRIAL ENGINEERING. *There are also a number of openings for majors in Metallurgy, Electronics, Mathematics and Physics.* Write now for further information: R. G. Greenwood, Engineering College Contact, Allison Division, General Motors Corporation, Indianapolis 6, Indiana.

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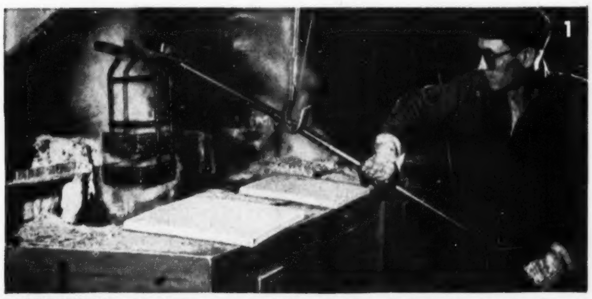
REX High Speed Tool Bits are made from high quality high-speed steel bar stock, produced at Crucible's Sanderson-Halcomb Mill. Bars are cut to tool bit lengths, heat-treated, grit-blasted or ground, and inspected.



1

**HARDENING** — Small batches of REX High Speed Tool Bits are hardened in modern salt bath furnaces. The bits are then quenched in either salt or oil.

2

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3

**TUMBLING** — Prior to inspection and packaging, REX High Speed Tool Bits are cleaned by tumbling.

4

**STOCKS** — REX High Speed Tool Bits are stocked in standard packages in Crucible's warehouses.

***Uniformity*** Each individual REX High Speed Tool Bit possesses the same uniform high quality. Each bit is inspected by the magnetic particle method . . . and representative bits are tested for microstructure and hardness. These tests control quality of the finished product . . . insure that REX bits will give higher production from each grind, and a minimum of "down-time" on your machine.

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National Drawn Works, East Liverpool, Ohio • Sanderson-Halcomb Works, Syracuse, N. Y. • Trent Tube Company, East Troy, Wisconsin

# STRESS and STRAIN...

*Verily, I say unto thee, marry not an engineer for an engineer is a strange being and possessed of many evils.*

*Yea, he speaketh in parables which he calleth formulae. He wieldeth a big stick which he calleth a slide rule. He hath only one Bible . . . . a handbook.*

*He thinketh only of stresses and strains, and without end of thermodynamics. He showeth always a serious aspect, and seemeth not to know how to smile. He picketh his seat in a car by the springs thereof, not by the damsels therein. Neither does he know a waterfall except by its horsepower, nor a sunset except by its physics, nor a damsel except by her mass. Always he carries his books with him and entertaineth his sweetheart with log tables.*

*Verily, although his damsel expecteth chocolates when he calleth, she opens the packet to discover samples of iron ore. Yea, he holdeth her hand to measure the compression strength thereof, and kisseth her to determine the specific heat of her lips, for in his eyes a desirous look, only a vain attempt to recall a variable constant. Even as a boy, he pulleth girls' hair to test its elastity. As a man he denieth different motives, for he counteth the vibrations of her heartbeat and seaketh to pursue his scientific investigations. He looketh upon even his own heart fluttering as a measure of fluctuations and describeth his passion as formulae and his marriage as a simultaneous equation involving two unknowns and yielding an extraneous root.*

* * *

Three deaf ladies were traveling on top of an open bus.

"Windy, isn't it?" said the first.

"No it isn't Wednesday, it's Thursday," said another.

"Yes, I'm thirsty too. Let's all get off and have something to drink," said the third.

* * *

*E E "Well, what would you like to drink?"*

*Coed: "I guess I'll have champagne."*

*E E "Well, guess again!"*

* * *

The truck knocked down the little old lady who was crossing the street.

Truck driver: "Look out!"

Old lady: "Why, are you coming back?"

* * *

And then there was the cross-eyed professor who couldn't control his pupils.

* * *

First man: "What makes you think Joe is so dumb?"

Second man: "Because he was looking in the post office on the wall and it says there on the sign, 'Man Wanted in Chicago for a Robbery, and he went in and applied for the job."

* * *

CE (finishing a letter to a friend): I'd send you that five I owe you, but I've already sealed the envelope.

Anyone who claims it is impossible to attain absolute zero hasn't taken a quiz in thermo lately.

* * *

*Did you ever hear of the waiter in an insane asylum who served soup to nuts?*

* * *

Then there was the overworked EE who told the story about the politically minded ion who heard there was going to be an electron so he went to the poles and volted.

* * *

*If she wants a date-Meter. If she wants an escort-Conductor.*

*If you thing she's picking your pocket-Detector. If she's slow of comprehension-Accelerator.*

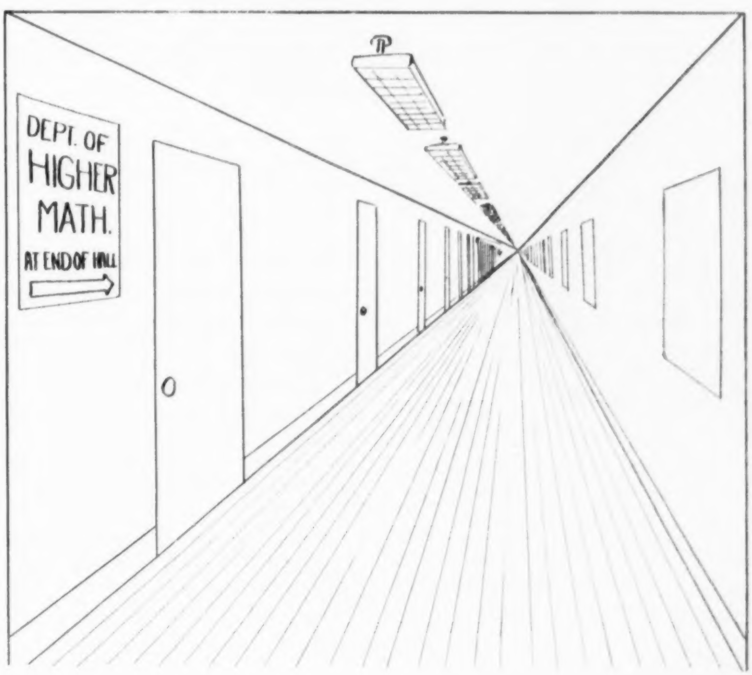
* * *

Doctor to patient: "You have only six more months to live."

Patient: "Then I'm going to become a Communist."

Doctor: "Why become a Communist?"

Patient: "Better one of them than one of us."



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Aircraft development is such an integral part of our national life that young graduates can enter it with full expectation of a rewarding, long-term career. Boeing, now in its 37th year of operation, employs more engineers today than even at the peak of World War II. Its projects include guided missiles, research on supersonic flight and nuclear power for aircraft.

Boeing engineering activity is concentrated at Seattle in the Pacific Northwest, and Wichita in the Midwest. These communities offer a wide variety of recreational opportunities. Both are fresh, modern cities with fine residential sections and shopping districts, and schools of higher learning where engineers can study for advanced degrees.

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• • •

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